DISTRIBUTIONS OF E. COLI AND ENTEROCOCCI IN THE SURFACE WATERS OF THE UPPER OCONEE WATERSHED OF GEORGIA

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ABSTRACT

The Upper Oconee watershed of Georgia is typical of the Piedmont and water quality is a key issue in the urbanization of this historically agricultural region. Fecal indicators may be found in higher numbers than regulatory targets and agricultural non-point sources are sometimes implicated. We enumerated E. coli and enterococci bacteria at 18 sites for 3 years (2200 observations) within the Upper Oconee watershed of Georgia in the Southern Piedmont of the USA. Contributing areas ranged from 1,500 to 40,000 ha. Even though both E. coli and enterococci are both used as fecal indicator organisms they were not highly correlated. High numbers of enterococci relative to E. coli may indicate wildlife sources. Cumulative distributions provided a means of comparing various regulatory threshold levels and the percentage of observations below the threshold. With the E. coli data pooled, approximately 25% of the samples were below 200 MPN/100 ml, approximately 68% were below 550 MPN/100 ml, and at 1000 MPN/100 ml only 82% of the samples had lower estimates. With the enterococci data, 38% of the samples were below 200 MPN/100 ml, 72% were below 550 MPN/100 ml, and approximately 82% of the samples were below 1000 MPN/100 ml. The two assays had similar distributions but enterococci numbers were more frequently (38% vs. 25%) below an MPN of 200 /100ml than E. coli. Both assays indicate contamination but lack of correlation may be related to source and viability in the watershed.

KEYWORDS. animal wastes, bacteria, fecal coliform, lakes, microbial, ponds, water quality.

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INTRODUCTION

Conservation programs and subsidies within USA agriculture have long relied on a voluntary approach to conservation on privately owned lands. The policies of the 1996 Farm Bill have increased local control of identification and prioritization of natural resource problems and sustainable land management solutions. The Farm Bill also broadened natural resource issues to address soil, water, wetlands, wildlife, and species preservation concerns while mandating programs to support animal based agriculture and grazing lands management (Zinn, 1997).

Pressure is increasing on the Environmental Protection Agency (EPA) and associated state agencies to improve water quality under the provisions of the 1972 Clean Water Act. Nearly 600 waterways in Georgia have been identified as impaired. As the EPA and Georgia Environmental Protection Division (GA-EPD) develop water quality standards for lakes and steams, agricultural producers may be identified as contributing to impairments and charged to reduce their inputs to acceptable levels. The effects of conservation practices on levels of fecal bacteria associated with animal based agriculture are relatively unknown.

For over 15 years, the EPA has encouraged the conversion from procedures estimating fecal coliform bacteria to methods that estimate E. coli and/or enterococci (EPA, 1986). The GA-EPD has recently drafted a rule change moving from a limit of 200 colony forming units per 100 ml for fecal coliform bacteria to 548 colony forming units per 100 ml for E. coli. Increasing the required geometric mean was proposed with little justification. In theory, an estimate of fecal coliform bacteria includes all E. coli and therefore a new standard for E. coli would be expected to be lower than a standard for fecal coliform. However, expected values for background levels of E. coli are relatively unknown making the establishment of a standard difficult.

We enumerated E. coli and enterococci bacteria at 18 sites for 3 years (2200 observations) within the Upper Oconee watershed of Georgia in the Southern Piedmont of the USA. We examined background levels and the relationship of E. coli to enterococci bacteria.

MATERIALS AND METHODS

Sampling continued for approximately 3 years on a 2 week interval at a total of 18 sites with contributing areas that ranged from 1,500 to 40,000 ha. Samples were collected at each site within an approximately 4 hour period and chilled while transported to the laboratory for analysis of microbe numbers.

Microbes were enumerated using the IDEXX (IDEXX Laboratories, Westbrook, Maine) procedures with the Colilert reagent for E. coli and the Enterolert for enterococci. For both assays the IDEXX Quanti-tray 2000 was used making it possible to estimate microbe numbers as high as 2,419 MPN/100 ml without dilution and we used dilution to measure samples above that number. Incubations were for 24 h and positive cells were detected by ultraviolet fluorescence.

RESULTS

Both E. coli and enterococci are used as fecal indicators suggesting a correlation (EPA, 2002). Previous work was often in proximity to a municipal discharge but in the current sampling of a broad group of land uses there was a notable lack of correlation between pairs of E. coli and enterococci estimates (Figure 1).

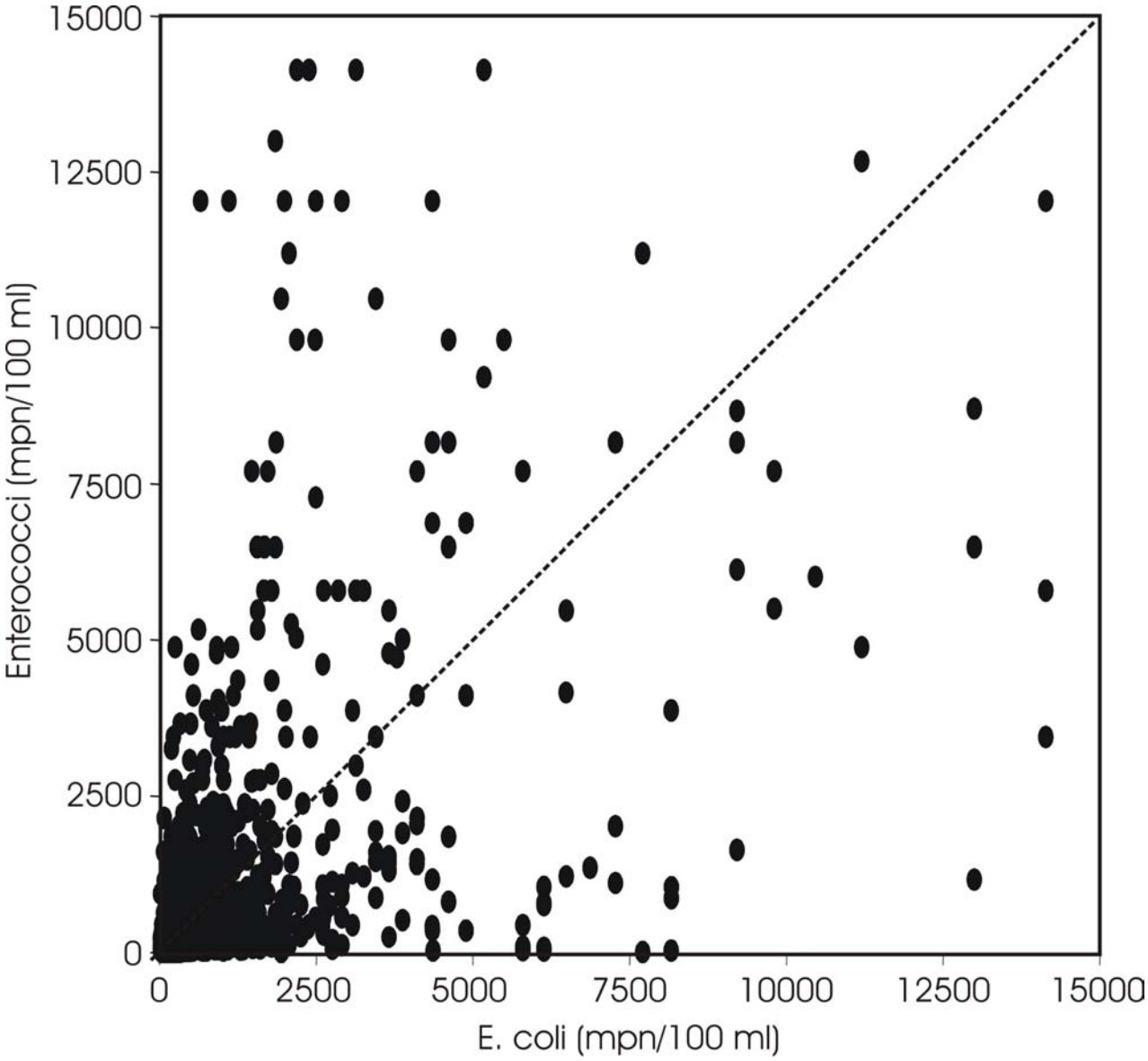

Figure 1. Lack of relationship between the two fecal indicator organisms E. coli and enterococci.

Since both assays indicate contamination by fecal material, the lack of correlation clearly indicates that the two assays present different information. This may be related to differences in longevity within the surface waters of the watershed or it may indicate widely differing proportions of E. coli to enterococci in the feces of the animals responsible for the contamination. It is likely that both processes are involved. Previous work has indicated that wildlife can produce a spike in enterococci numbers that isn't mirrored by a spike in E. coli numbers (Fisher et al., 2000).

The cumulative distribution of estimated microbe numbers makes it possible to predict the percentage of samples passing at any single day standard (Figure 2). In addition to the plot of the cumulative distribution of the E. coli, the estimates of fecal coliform bacteria from the same watershed during at different time period and at differing sites makes it possible to compare both distributions. The two curves begin to diverge approximately at the current standard of 200 MPN/100 ml. In both cases only 25 % of the samples are below this level. Above approximately 200 MPN/100 ml the two curves diverge with E. coli numbers generally smaller (more observations pass each level of microbes resulting in the upper curve) than numbers of fecal coliforms. The relationship of the two curves is consistent with theory since E. coli should be a sub-sample of microbes enumerated as fecal coliforms. The median level of E. coli was approximately 300 MPN/100 ml while the median level of fecal coliforms was just under 500 MPN/100 ml.

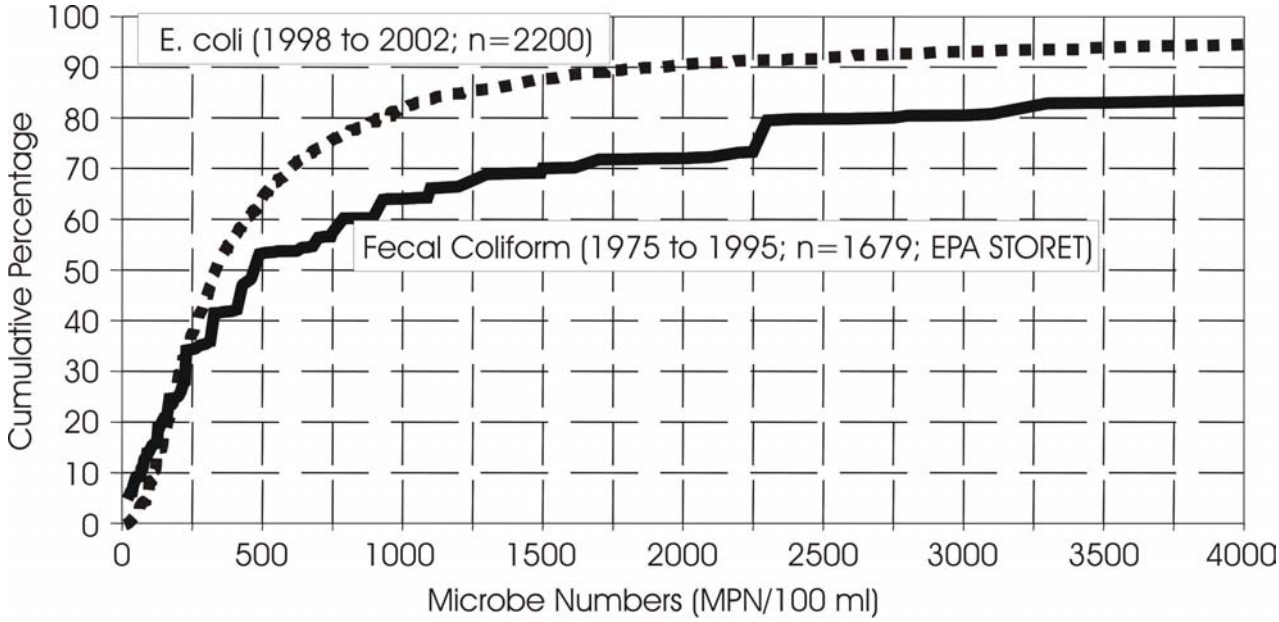

Figure 2. Cumulative percentage below each estimate of microbe numbers in the Upper Oconee Watershed of Georgia for E. coli and fecal coliform bacteria. Dashed curve is based on estimates of E. coli collected in this study while the lower solid line is based on estimates of fecal coliform bacteria from the EPA STORET system.

Approximately 25% of the E. coli samples were below 200 MPN/100 ml, approximately 68% were below 550 MPN/100 ml, and at 1000 MPN/100 ml approximately 82% of the samples had lower estimates. The curve for the enterococci observations was very similar (data not shown) with 38% of the samples below 200 MPN/100 ml, 72% below 550 MPN/100 ml, and approximately 82% of the samples were below 1000 MPN/100 ml.

CONCLUSION

The use of 200 MPN/100 ml as a standard for the geometric mean of 4 observations is a difficult standard to meet within the Upper Oconee Watershed. If storm influenced samples are eliminated it becomes more attainable even though only 25% of the individual samples met the criteria.

Theoretically, retaining a 200 MPN/100 ml for E. coli should be an easier standard to meet than 200 MPN/100 ml for fecal coliforms since the E. coli are a subset of the fecal coliforms. Raising the standard to over 500 MPN/100 ml would result in fewer water bodies being designated as impaired although it should identify the problem areas of the watershed.

The lack of correlation between the assays for E. coli and enterococci warrants additional research. It is possible that the use of both assays may help identify wildlife impacts.

REFERENCES

1. EPA. 1986. Ambient water quality criteria for bacteria - 1986. EPA-440/5-84-002. Office of Water Regulations and Standards, Criteria and Standards Division, Washington, DC.
2. EPA. 2002. Implementation guidance for ambient water quality criteria for bacteria. U.S. Environmental Protection Agency. EPA-823-B-003. Office of Water, Washington, DC.
3. Fisher, D.S., J.L. Steiner, D.M. Endale, J.A. Stuedemann, H.H. Schomberg, A.J. Franzluebbers, and S.R. Wilkinson. 2000. The relationship of land use practices to surface water quality in the Upper Oconee Watershed of Georgia. Forest Ecology and Management 128:39-48.
4. Zinn, Jeffrey. 1997. After the 1996 Farm Bill - Challenges of change, a white paper report. J. Soil and Water Conservation 52:147-150